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10/535478

JC14 Rec'd PCT/PTO 17 MAY 2005

SPECIFICATION

Injection Apparatus in Cold Chamber Die Casting Molding Machine and ~~Measuring Method used therein~~

Technical Field

This invention relates to an injection apparatus in a cold chamber die casting molding machine. More specifically, this invention relates to an injection apparatus, which replenishes light metal material into its melting device in the form of a billet such as a short cylindrical rod for melting and supplies the molten metal into a plunger injection device for measuring. Moreover, this invention relates to measuring method for the cold chamber die casting molding machine.

Background Art

An injection molding machine for light metal alloys such as magnesium, aluminum, zinc is generally called a die casting molding machine, and is classified into a hot chamber method machine and a cold chamber method machine. The former hot chamber machine, in which an injection device is provided on a furnace, measures one shot of the molten metal in an injection sleeve of the injection device by sucking the molten metal from the furnace, and injects it into a mold cavity with a plunger. With this method of machine, molten metal of high temperature is supplied stably into the injection sleeve. On the other hand, the latter cold chamber machine, in which an injection sleeve is positioned out of a furnace, measures the molten metal by transferring it from the furnace to the injection sleeve with a pump or a ladle, and injects it with a plunger. With this method of machine, since the injection device is provided separately from the furnace, maintenance work becomes easy.

However, with the above described method of molding machine, since the furnace has very bulky volume compared to that of molded articles and great

volume of molten metal has to be kept at the specified high temperature, higher running cost is needed. In addition, it takes a long time to raise or lower the furnace temperature. Maintenance work for the furnace may need a whole day. Especially in case the molding material is magnesium alloy, since magnesium is extremely easy to be oxidized and to catch fire, it is necessary to occasionally remove sludge including magnesium oxide. Moreover, surface area of the molten metal in the furnace is too large to prevent generation of the sludge although much non-burning flux or inert gas is poured into the furnace. To make matters worse, this sludge causes wear of the injection sleeve and the plunger.

Therefore, an injection apparatus for supplying molding material directly to a plunger injection device without adopting the furnace has been proposed. For example, an injection apparatus having a material supply device capable of supplying light metal material in the form of a short cylindrical rod-shaped billet or ingot, is known. This type of an injection apparatus generally injects semi-solidified molding material into the mold. With this injection apparatus, the problem relating to the above described furnace is solved and the oxidation of a magnesium alloy is also decreases.

More specifically, one of this injection apparatus is provided with a heating sleeve which accommodates plural ingots for heating preliminary, an injection sleeve which contains a plunger, and a chute which leads the ingot from the heating sleeve to the injection sleeve, wherein the ingots have been formed into the size for one shot of injection amount by other forming apparatus beforehand. (For example, see patent document 1, whose number is shown later) This injection apparatus transfers the ingots, which has been heated and softened in the heating sleeve, to the injection sleeve, and then injects the material, which has been turned into semi-molten state, into the mold with the plunger pressurizing. Another type of this injection apparatus is provided with a forming-hole (dice) and a cutter plate at the front end of a heating sleeve, which forms and cuts off the billet to make it match the injection sleeve, wherein the billet corresponds to the above described ingot.

(See patent document 2) In this apparatus, the outside diameter of the billet is formed to fit with the inside diameter of the injection sleeve and the overall length of the billet is cut off so as to become one shot of injection amount. Therefore the troublesome problems as shown in patent document 1, such as the increase of the variety of the ingots and the related preliminary heating condition settings, are solved, which makes it unnecessary to prepare many kinds of ingots for every molded article beforehand.

On the other hand, an injection apparatus different from the above described method apparatus is proposed. (See patent document 3) This injection apparatus has a high temperature cylinder section at mold side (front side close to a mold), a low temperature cylinder section at rear side (base side), and a heat insulating cylinder section between them. With this injection apparatus, molding material, which is beforehand formed into a cylindrical rod, is inserted into the above described injection cylinder, and then melts in the high temperature cylinder section, and finally its molten metal is injected by the not-yet-melted molding material. Since the molding material is injected not by a plunger but by the not-yet-melted molding material itself, this molding material is called a self-consumption plunger in this specification. This type of injection apparatus does not need a furnace, so it makes the structure of its melting device vicinity simple and also enables efficient melting. Moreover, this injection apparatus does not need a plunger, which achieves reduction of wear of the injection cylinder and short time maintenance work.

Afterward, the above applicant has proposed the similar injection apparatus (See patent document 4), but this document mainly discloses an injection apparatus for preventing seizure of glass forming.

Incidentally, the patent documents quoted above are:

Patent document 1 - Japanese patent No. 2639552,

Patent document 2 - Japanese patent laid-open No. 2001-191168,

Patent document 3 - Japanese patent laid-open No. Hei. 05-212531, and

Patent document 4 - Japanese patent laid-open No. Hei. 05-254858.

However, above described injection apparatus of both the hot chamber method machine and the cold chamber method machine include some problems concerning the above described furnace. Also, the injection apparatus described in the patent document 1 and 2, which do not contain above described furnace, have such a limitation that they are not suitable for molding particularly thin walled and/or precise geometry articles, since they are not the apparatus to inject fully molten metal. When this type of injection apparatus tries injection with fully molten molding material regardless of this limitation, the longer waiting time is required for changing the material into fully molten matter.

Another patent document 3, which adopts a self-consumption plunger, is neither disclosing the length of the molding material and its supply method. Moreover the patent document 3 is neither disclosing the solution for the following phenomenon although such a phenomenon occurs often. That phenomenon is that the movement of the plunger is impeded and so the injection becomes often impossible at the time of injection process, since the molten metal, which has low viscosity and high pressure, flows backward through the gap between the injection sleeve and the self-consumption plunger, and then is solidified accompanying increased frictional resistance. That is because the injection apparatus functions as an injection apparatus as well as as a melting device and hence the pressure of molten metal becomes high. Also, in case a self-consumption type plunger is installed horizontally in the injection sleeve, above described phenomenon becomes more remarkable since the gap between the plunger and the injection sleeve becomes larger at its upper side. That is because the outside diameter of the self-consumption plunger is manufactured rather thinner than the inside diameter of the injection sleeve anticipating thermal expansion. Moreover, above described phenomenon becomes more pronounced in case the solidified matter of the molten metal is destroyed and re-formed at many times of injection molding operation and as a result grows up widely and hardly. In particular, in case of molding for particularly thin walled shape and/or particularly complicated geometry shape, the

occurrence of the above phenomenon becomes more remarkable, since an injection is carried out under high speed and high pressure in this case.

Above described similar patent document 4 is neither solving the above phenomenon of light metal molding, since it discloses the seizure prevention technology of glass forming. That is, above described seizure prevention art is cooling technology for promoting cooling of molding material with the plural grooves or spiral grooves on the cylinder wall. In this case of glass forming, above described operational effect at the above grooves and so on is supposed to be actually effective since molten grass does not fills up above described grooves rapidly because of high viscosity of its softened matter at comparatively wide temperature range inherent to glass. On the contrary, in the case of light metal molding, light metal melts and solidifies rapidly due to small specific heat, small latent heat, and high coefficient of thermal conductivity inherent to light metal. In addition, the temperature range at which light metal is in a softened state is narrower than that of glass and also the molten metal presents extremely low viscosity fluidity. Therefore the molten metal is intruded into the above described grooves rapidly and solidifies rapidly, and thus the grooves do not function as cooling grooves or as deformation absorption grooves. Accordingly, the injection apparatus in above described patent document 3 and document 4 are still incomplete to inject molten light metal stably.

Therefore, the object of this invention is to provide such an injection apparatus that makes the conventional furnace unnecessary and makes it possible to replenish a light metal material in the form of the billet and to supply said material into an injection device in the form of full molten material, wherein said injection apparatus can feed and melt a light metal materiel with efficiency and can measure one shot of injection amount of molten metal with accuracy.

Disclosure of the Invention

According to the present invention,

an injection apparatus in a cold chamber die casting molding machine, which supplies molten metal of light metal material into a material supply mouth of an injection sleeve and has a plunger injection device which injects said molten metal by a plunger, is comprising:

(a) a melting device which melts said light metal material, and a molten metal feeding member which pours molten metal from said melting device to said plunger injection device;

(b) wherein said melting device further includes:

a billet supplying device which replenishes the molding metal by supplying said light metal material in the form of a billet of the short cylindrical rod shape,

a billet inserting device which is situated behind said billet supplying device and has a pusher for moving said replenished billet forward or for retreating the distance which exceeds overall length of said billet, and

a melting cylinder which is situated in front of said billet supplying device for accommodating said plural billets moved forward by said pusher and for melting from the front end of said billets so as to form several shots of molten metal;

(c) wherein said molten metal feeding member further includes a material supplying hole for pouring said molten metal from the front end of a cylinder bore of said melting cylinder to said material supply mouth of said injection sleeve; and

(d) wherein said melting device measures said molten metal by pushing said billet via said pusher and by supplying one shot of said molten metal into said injection sleeve after said plunger injection device makes said plunger retreat.

By virtue of this type of structure, the melting device of the injection apparatus of this invention replenishes light metal material in the form of the billet of a short cylindrical rod shape and melts only the minimum quantity for supplying the molten metal to the injection sleeve. Therefore, heating and solidifying in the melting cylinder can be done for a short time and hence it is possible to finish maintenance work of the injection apparatus fast. Moreover the heating energy for melting the material in the melting device decreases and hence heating becomes

efficient. Also, the volumetric size of the melting device becomes remarkably smaller than that with the conventional furnace. In addition, the handling becomes easy because the light metal material is supplied in the form of the billet. In particular, in case the billet is magnesium material, another advantage that it is difficult for the billet to oxidize is gained.

Preferably, said melting cylinder of said injection apparatus in a cold chamber die casting molding machine is composed by such a first melting cylinder that most of a cylinder bore except for base side of said first melting cylinder is formed to have an inside diameter which keeps said most of the cylinder bore into contact with an enlarged side surface of not-yet-melted front end of said billet with the degree which prevents the backward flow of said molten metal, and a cylinder bore of said base side of said first melting cylinder is formed to have a slightly larger diameter than an outside diameter of said billet.

With this construction of the injection apparatus of this invention, the melting device is composed by such a first melting cylinder that most of the cylinder bore of the first melting cylinder which excludes the base side is formed to have an inside diameter which keeps said most of the cylinder bore into contact with the enlarged side surface of front end of billet with the degree which prevents the backward flow of the molten metal at the time of measuring, and that the cylinder bore of the base side is formed to have such an outside diameter that is a slightly larger than that of the billet. Therefore the enlarged side surface prevents the leakage of the molten metal to the backward and the invasion of air and the like into the molten metal as an enlarged diameter seal member and hence functions as the seal with small frictional resistance. Moreover, since the first melting cylinder and the pusher do not contact each other, they are not badly worn and maintenance work of the melting device becomes easy. This type of melting cylinder is so simple that it is effective when it is adopted for a small-sized injection molding machine.

Preferably, said melting device of said injection apparatus in a cold chamber die casting molding machine is comprising:

(a) a cooling member which cools said billet,

a second melting cylinder which is fixed in front of said cooling member, and

a cooling sleeve which is situated between said second melting cylinder and said cooling member;

(b) wherein said cooling member has a through hole with a diameter a slightly larger than the outside diameter of said billet and has a cooling duct around said through hole;

(c) wherein most of the cylinder bore of said second melting cylinder is formed to have an inside diameter which does not allow said most of the cylinder bore to come into contact with said front end of said billet; and

(d) wherein said cooling sleeve has a circular groove which generates a circular solidified material of said molten metal on the periphery of said billet by cooling said molten metal

With this construction, the melting device of the injection apparatus of this invention contains such a cooling sleeve between said second melting cylinder and a cooling member, that said cooling member has the hole of the inside diameter which is a slightly larger than the outside diameter of the above described billet, and that said most of the cylinder bore of the second melting cylinder is formed to have an inside diameter which does not allow said most of the cylinder bore to come into contact with the front end of the billet, and that the cooling sleeve has a circular groove which generates a circular solidified matter from said molten metal by cooling it. Therefore the circular solidified material prevents the leakage of the molten metal to the backward and the invasion of air and the like into the molten metal as a circular solidified material seal, and also functions as a seal with small frictional resistance. This type of melting cylinder is effectively adopted at a large-sized injection molding machine as well as a small-sized injection molding machine.

Preferably, said material supplying hole of said molten metal feeding member of said injection apparatus in a cold chamber die casting molding machine

leads to said cylinder bore of said melting cylinder via a connecting passage that is opening at the upper portion of said cylinder bore of said melting cylinder and, said melting cylinder is arranged in the inclined posture in which the front portion is high position.

With this construction of the injection apparatus of this invention, the material supplying hole of the molding material feeding member leads through a connecting passage which opens at the upper portion of the cylinder bore of the melting cylinder, and the melting cylinder is arranged in the inclined posture with its front side high. Therefore the air and the gas which remains in the melting cylinder at first is purged promptly and the phenomenon in which molten metal in the melting cylinder over-flows into the injection sleeve at unexpected timings except for the measuring timing is prevented, which ensures the measuring accurate.

Preferably, such an opening and shutting device of said injection apparatus in a cold chamber die casting molding is provided between said melting device and said plunger injection device, that contains a valve rod for opening and shutting the bottom end of said material supplying hole by going up and down in said material supplying hole, and a valve rod driving device for opening said valve rod only at the time of measuring.

With this type of structure, since said valve rod opens the bottom end of said material supplying hole only at the timing of measuring, dropping of the molten metal in the material supplying hole at unexpected timings except for the measuring timing is prevented, which assures accurate measuring.

The measuring method used in said injection apparatus in a cold chamber die casting molding machine, in which said opening and shutting device opens and shuts said material supplying hole, is performed as follows that said molten metal is measured in such a manner that said molten metal is always stored in said material supplying hole with the opening and shutting operation of said material supplying hole and the extruding operation of said pusher performed almost simultaneously.

In this measuring method, since the opening and shutting operation of the material supplying hole by means of the opening and shutting device and the extruding operation of molten metal by means of the pusher are performed simultaneously, solidification of molten metal in the material supplying hole is prevented and moreover adhesion of molten metal to the material supplying hole or the valve rod is evaded, which ensures accurate measurement control.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a cross-sectional elevation view showing outline structure of an injection apparatus in a cold chamber die casting molding machine of this invention. Fig. 2 is a cross-sectional view showing a first melting cylinder for the first embodiment of this invention. Fig. 3 is a cross-sectional view showing a second melting cylinder for the second embodiment of this invention. Fig. 4 is an enlarged cross-sectional view of base portion of the second melting cylinder illustrated in Fig. 3. Fig. 5 is an enlarged cross-sectional view showing structure of a opening and shutting device equipped in a molten metal feeding member of this invention. Fig. 6 is a cross-sectional view, taken along line X - X of Fig. 1, showing a billet supplying device of an injection apparatus in a cold chamber die casting molding machine of this invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

An injection apparatus in a cold chamber die casting machine of this invention is described as follows using illustrative embodiments.

First of all, light metal material to be supplied into this injection apparatus is described. The light metal material is formed into a shape of a short rod which is cut off beforehand at a specified length from a cylindrical bar. This light metal material is hereinafter called a billet. Reference numeral 2 denotes the billet, and its periphery surface and cut off end surface is finished smooth. The outside diameter of this billet is formed to secure 0.2 mm to 0.5 mm thinner than the inside diameter

of a base end side (the right side in the drawing) of a cylinder bore 11a of a melting cylinder 11 when this billet has expanded after heated as described later. The length of this billet 2 is formed to correspond to the volume of from ten several shots to a few tens shots of injection amount, and, for example, is formed to be about 300 mm to 400 mm for the sake of its handling. Since the light metal material is supplied in this form of billet, storage and handling of the materials becomes easy. Especially in the case where the billets 2 are made of magnesium material, the billets have such an advantage that they are more difficult to oxidize than the palletized metal which is used conventionally in the thixotropic molding, since the surface area with respect to the volume is small. Incidentally the above described one shot of injection amount is the sum of the volume of molten metal for one shot injection, which involves the volume of molded articles and the accompanying volume, such as a spool, runner, and the thermal shrinkage volume.

Next, the outline of the embodiments of the injection apparatus in a cold chamber die casting molding machine of this invention is described. As shown in Fig. 1, this injection apparatus 1 includes a melting device 10, a plunger injection device 20, and a molten metal feeding member 15 which pours molten metal from the melting device 10 to the plunger injection device 20.

The melting device 10 is different from the conventional injection apparatus of cold chamber die casting molding machine in such a manner that light metal material is replenished in the form of billets as described above. This melting device 10 comprises the melting cylinder 11, a billet supplying device 40 and a billet inserting device 50. The melting cylinder 11 and the billet inserting device 50 are fixed to a central frame member 90. The central frame member 90 is a member for mounting the billet supplying device 40 and is composed of four rectangle side plates 90a and a single bottom plate. In one of two opposing plates 90a, a through hole 90b having a diameter slightly larger than the outside diameter of a billet 2 is formed. In the other of opposing plates 90a, a through hole 90c is formed, in which a pusher 52a goes forward and backward as described later. The melting cylinder

11 is a long cylinder formed to have such a length as to accommodate plural billets 2. Most of the cylinder bore 11a except for the vicinity of the base end is formed to have a larger diameter than that of a billet 2 as described later. The front end of this cylinder bore 11a is blocked by an end plug 13 but the cylinder bore 11a leads to a material supplying hole 15a in the molten metal feeding member 15 as described later. With the melting device 10 composed in this way, the billets 2 are replenished one by one to the rear of the melting cylinder 11 by the billet supplying device 40, and inserted into the melting cylinder 11 by the plunger 52a of the billet inserting device 50 so as to melt from its front end. The amount of molten metal 3 is controlled to secure several shots of injection amount as described later. The more detail of the melting cylinder 11, the molten metal feeding member15, the billet supplying device 40 and the billet inserting device 50 is described later.

The plunger injection device 20 is basically the same as that of the conventional injection apparatus in the cold chamber die casting molding machine, and includes an injection sleeve 21, a plunger 22 and a plunger driving device 60. The injection sleeve 21 and the plunger driving device 60 are arranged in series on a single line by a connecting member 64. The injection sleeve 21 has a sleeve bore 21a for storing molten metal 3 temporarily and has a material supply mouth 21h on the upper portion, through which molten metal 3 is poured. The front end (the left side in the drawing) of the injection sleeve 21 goes through a stationary platen 31 and a mold half 32. The plunger 22 is connected at its base end to a piston rod 62 of the plunger driving device 60, and is subjected to control of movement in a longitudinal direction in the injection sleeve 21. This plunger injection device 20 mounts the melting device 10 via the central frame member 90. The central frame member 90 is fixed on a connecting base member 92 arranged on the plunger driving device 60. The plunger driving device 60 is placed on a slide base 91 of a machine base frame. (Not shown in the drawing) The plunger injection device 20 fills molten metal 3 into a cavity 34 with the plunger 22. The more detail of the injection sleeve 21, the plunger 22, the connecting member 64 and the plunger

driving device 60 are described later. Incidentally the mold halves 32 and 33 compose conventional mold unit, the mold half 32 is fixed on the stationary platen 31 of a clamping device 30, and so the cavity 34 is formed when the mold halve 33 is closed.

The material supplying hole 15a in the molten metal feeding member 15 fixed near the front end of the melting cylinder 11 leads to the cylinder bore 11a through a connecting passage 13a and 13b in the end plug 13. The lower portion of the molten metal feeding member 15 and the material supply mouth 21h are covered with a cover 16. A pouring hole 17 through which inert gas is filled leads to the connecting passage 13a, the material supplying hole 15a or the cover 16. For example in Fig. 1, this pouring hole 17 is formed in the end plug 13, whereas in Fig. 5 it is formed on the cover 16 as described later. Inert gas filled through this pouring hole 17 purges out air in the material supplying hole 15a and the injection sleeve 21. The oxidation of the molding material such as magnesium alloy which is easy to oxidize is particularly prevented by this purge.

On this type of the melting cylinder 11 of the injection apparatus 1, for example, heaters 12a, 12b, 12c and 12d like heater bands are wrapped so as to melt the billet 2 from its front end first. Moreover, a heater band 18 and a heater band 23 are wrapped around the molten metal feeding member 15 and the injection sleeve 21 so as to keep molten metal 3 in a molten state. These heater bands control their vicinities to specified set up temperature based on the feedback temperature from sensors not shown in the drawing. For example, in case a billet 2 is magnesium alloy, temperature of the heater bands 23 and 18 is set to about 600 ℃ to 650 ℃. Temperature setting of heater bands 12a, 12b, 12c and 12d are described in detail later. Incidentally, melting cylinder 11 may be made of ceramics and the like, and so the heater bands may be an induction-heating coil.

Next, the embodiment of the melting device 10 that discloses characteristic features of this invention the most is described in detail. First of all, two embodiments of the melting cylinder 11 are described. Fig. 2 is a cross-sectional

side view showing the first embodiment. Fig. 3 is a cross-sectional side view showing the second embodiment. Fig. 4 is an enlarged cross-sectional view of base portion of Fig. 3.

Reference numeral 111 in Fig. 2 denotes the first melting cylinder of the first embodiment. Most of a cylinder bore 111a of this cylinder 111 except for the vicinity of the base end is formed to have a few mm larger diameter than the billet 2 and the base end of this cylinder bore 111a has a slightly larger diameter than the billet 2. Between them, a stepped section 111d is formed. In case this melting cylinder is for melting magnesium alloy, the gap of a larger diameter cylinder bore 111b with regard to the billet 2 is formed to secure about 1 mm to 2 mm. Also the gap of a base end side of the cylinder bore 111c with the billet 2 which has expanded thermally slightly, is formed to secure about 0.2 mm to 0.5 mm. The position of the stepped section 111d is formed beforehand at an appropriate position in accordance with some conditions, such as the inside diameter of the melting cylinder 111, the volume of molten metal 3, temperature setting of the heater band 12c, 12d, or the gap of the larger diameter cylinder bore 111b with the billet 2. Incidentally, the inside diameter of a cylinder bore 111c of base end side represents a cylinder diameter which shows one of specification indexes of the injection machine.

Reference numeral 211 in Fig. 3 denotes a second melting cylinder of the second embodiment. This melting cylinder 211 is combined with its base end to the side plate 90a of the central frame member 90 by bolts 213 along with a cooling sleeve 212 which is described later. In this embodiment, a cooling duct 90d for circulating cooling fluid is formed at the periphery of the through hole 90b of the side plate 90a. Therefore the side plate 90a functions as a cooling member and hence is also called a cooling member 214 in the following description. As a matter of course, this cooling member 214 may be composed as the different part from the side plate 90a and may be arranged at any place as long as it is furnished between melting cylinder 211 and the side plate 90a. In case the billet 2 is magnesium alloy

the gap between the through hole 90b and the billet 2 is formed to secure about 0.2 mm to 0.5 mm when the billet 2 has expanded thermally slightly. Owing to this gap in the through hole 90b and this cooling operation by side plate 90a, billets 2 are inserted without interfering with the through hole 90b, and is maintained in such a non-softened state that the billet 2 does not deform with the pressure of molten metal 3 which rises a little at the time of measuring.

The inside diameter of the cylinder bore 211a of above described second melting cylinder 211 is formed a few mm larger than billet 2. For example, in case molding metal is magnesium alloy, the gap with respect to the billet 2 is formed about 1 mm to 3 mm larger. The operational effect of this gap is described later. The melting cylinder 211 also has an annular protrusion 211e of the shape of the sleeve on the outer side of the base end as shown in Fig. 4, and forms a space 215 in combination with the cooling sleeve 212, and the cooling member 214. This annular protrusion 211e has plural holes or cutouts 211f from which heat confined in this space 215 is dissipated. Therefore this space 215 functions as a heat insulating space between the cooling member 214 and the melting cylinder 211.

The cooling sleeve 212, fixed between the base end of the melting cylinder 211 and the side plate 90a of a cooling member 214, is formed to be a small and substantially thin cylindrical member so that the contact surfaces to them become as small as possible. This cooling sleeve 212, as shown in Fig. 4, is fitted in a bored hole on the front surface of cooling member 214 and a bored hole on the base end of melting cylinder 211. This cooling sleeve 212 also has a temperature sensor not shown in the drawing and its temperature is detected.

In a hole of the cooling sleeve 212, as shown in Fig. 4, an circular groove 212a is formed, in which molten metal 3 flown backward along the periphery of the billet 2 is solidified and held. This circular groove 212a is formed to be 20 mm to 40 mm in width, preferably 30 mm, and 3 mm to 4 mm in depth with respect to the cylinder bore 211a in case the billets 2 are magnesium alloys. Besides, the inside diameter of a hole 212b of the cooling sleeve 212 at the front side of the circular

groove 212a is formed to be equal to that of cylinder bore 211a, and the inside diameter of a hole 212c at the backward side of the circular groove 212a is formed to be equal to that of the through hole 90b. Since the circular groove 212a is formed in the cooling sleeve 212 which contacts the cooling member 214, the circular groove 212a is cooled powerfully by the cooling member 214. The operational effect of this circular groove 212a is described later. Incidentally, the circular groove 212a is formed to be contained completely in the cooling sleeve 212 as shown in Fig. 4, but it may be formed to have a contact with either side of the melting cylinder 211 or the cooling member 214.

In particular, it is desirable that the cooling sleeve 212 is made of such a material that is equivalent to the melting cylinder 211 and/or the cooling member 214 in rigidity and thermal expansion, and is made of the material that has as good thermal conductivity as possible. This means that cooling sleeve 212 may be formed together with either the melting cylinder 211 or the cooling member 214. Moreover, the cooling sleeve 212 has no problem in stiffness although being made of a small volume member as illustrated, namely, a comparatively thin cylindrical member. That is because a circular solidified material 201, which is formed in the circular groove 212a as described later, prevents molten metal 3 from leaking backward beyond this circular solidified material 201 and hence suppresses high pressure.

With regard to above described heater bands 12a, 12b, 12c and 12d of the first melting cylinder 111 and the second cylinder 211, three front side heater bands 12a, 12b and 12c are set to the melting temperature of the billets 2. For example, in case billet 2 is magnesium alloy, temperature of these heater bands are set to about 600 ℃ to 650 ℃. On the contrary, temperature setting of the heater band 12d for the first melting cylinder 111 and that for the second cylinder 211 differs a little.

The temperature setting of heater band 12d of the first melting cylinder 111 is controlled appropriately at about 450 ℃ to about 550 ℃ so as to suppress softening of billet 2 that is positioned at the base end of melting cylinder 111. That

is because magnesium alloy begins to soften materially when it is heated to about 350 ℃. By being heated in this way, the billet 2 is preliminary heated to the extent that it does not soften in the base end of the melting cylinder 111, then is heated at high temperature in the portion from the halfway to the front end of the cylinder 111 while advancing inside the cylinder bore 111a, and finally melts rapidly into molten metal 3 of temperature 600 ℃ to 650 ℃ at the front end of the cylinder 111. In this embodiment, the side plate 90a of the central frame member 90 is not heated generally, and so the plate 90a, in some case, may be cooled by the cooling pipe like the cooling duct 90d of the second melting cylinder 211.

On the other hand, the heater band 12d of the second melting cylinder 211 is fixed at the position apart from the vicinity of the base end where the cooling sleeve 212 is attached, and heating influence to the cooling sleeve 212 is suppressed as much as possible. The temperature setting of the heater band 12d is controlled at about 500 ℃ to 550 ℃. Therefor, the cooling sleeve 212 is not subjected to heating but is cooled strongly by the cooling member 214. Accordingly, temperature of cooling sleeve 212 is controlled mainly by cooling temperature setting of the cooling member 214, and is subsidiary controlled by this heater band 12d. As a matter of course, the plumbing through which the coolant goes may be turned around the cooling sleeve 212 and the temperature may be individually controlled. More specifically, in case of magnesium molding, temperature of billet 2 in the cooling member 214 may be cooled as not to exceed about 100 ℃ to 150 ℃, and temperature of billet 2 in the cooling sleeve 212 may be controlled to become about 400 ℃ which is close to the temperature 350 ℃ at which the softening occurs a little.

Since the billet 2 is heated in the first melting cylinder111 or in the second melting cylinder 211 as described above, the billet 2 melts from its front end and turns into molten metal 3. Then, temperature is controlled so that several shots of injection amount is secured while the volume of this molten metal 3 fluctuates at every time of the measuring process of molding operation. In this manner, the

minimum amount of material is only melted and secured in the melting device 10 and thus heat energy is reduced efficiently. Moreover, time for raising or cooling down the temperature is reduced, which minimizes wasteful waiting time for maintenance work and inspection work. Moreover, the volumetric size of the melting device becomes much smaller than the conventional furnace.

As a matter of course, backward flow of molten metal 3 through the gap between the billet 2 and the melting cylinder 11 has to be surely prevented when molten metal 3 for one shot amount is supplied to the injection sleeve 21 from the melting cylinder 111 or 211, namely measured. Such sealing is done by the following method in both the first melting cylinder 111 and the second melting cylinder 211.

In the first embodiment, at the time of measuring, the front end of the softened billet 2 is enlarged diametrically a little due to a little pressure rising of the molten metal 3. Then a side surface 2a of the enlarged front end seals molten metal 3 by being kept into contact with the wall surface of the larger diameter cylinder bore 111b appropriately. This sealing is performed when this enlarged side surface 2a keeps contact with the wall surface of the cylinder bore 111b appropriately, and hence this sealing is realized by the appropriate gap size between them. In this case, it is convenient that the pressure rise of molten metal 3 at the time of measuring is a little, which does not cause the diametrical expansion of above described side surface 2a too much. Moreover, eccentricity of the billet 2 with the cylinder bore 111b is suppressed and hence the gap between the base end side cylinder bore 111c and billet 2 becomes small and is minimized equally. In addition, the side surface 2a keeps contact with the cylinder bore 111b appropriately as a soft and uniformly enlarged seal, since such a surface 2a is kept in the appropriately softened state by heating of the heater bands 12a to 12d and cooling of the cooling member 214. Therefore the side surface 2a functions as a seal of low frictional resistance and as a seal which also prevents intrusion of air and the like or leakage of molten metal 3.

Accordingly the side surface 2a enlarged diametrically of this embodiment is termed an enlarged diameter seal member in the following description.

In this embodiment, the gap between the larger diameter cylinder bore 111b and the billet 2 has to be set up beforehand appropriately in accordance with molding condition as described above. However above described first melting cylinder 111 can be sufficiently easily adopted for a small-sized injection molding machine with comparatively small inside diameter of the melting cylinder 111. That is because the melting cylinder 111 that is simply composed of above described cylinder bore 111b, 111c meets with cost reduction request which is necessary for a small-sized injection molding machine. Moreover, such a small-sized injection molding machine does not cause backward flow phenomenon of molten metal so much as a large-sized injection molding machine. The above described will be easily understood by such a phenomenon that the diameter of the billet 2 in a large-sized injection molding machines is so thick and hence the peripheral length is so long that the gap through which molten metal flows backward becomes larger.

On the other hand, in the second embodiment, molten metal 3 is not sealed by above described enlarged diameter seal member but is sealed by a circular solidified material seal which is the solidified matter of molten metal 3 in the circular groove 212a of the cooling sleeve 212. The seal of this circular solidified material seal is described as follows.

In case of magnesium alloy, the billet 2 in the cooling sleeve 212a is controlled to be at about 400 ℃ near its softening temperature by being powerfully cooled by cooling sleeve 212. In this condition, when the injection apparatus 1 first commences its preparatory injection molding operation, the billet 2 advances at low speed as described later. Then the molten metal 3 which has already melted at the front end of the melting cylinder 211 flows backward along the billet 2 while filling the circular groove 212a up, and finally changes into solidified matter. This solidified matter, as the circular solidified material 201, has the characteristics as follows.

First, since this circular solidified material 201 is the solidified material of molten metal 3 that is following the shape of the space between the circular groove 212a and the billet 2, it fills the periphery space of the billet 2 with no gaps even if there exists slight eccentricity of the billet 2 with the melting cylinder 211. Next, since the greater part of the circular solidified material 201 is fitted in the circular groove 212a in the solidified state, the circular solidified material 201 neither advances with the billet 2 nor breaks due to the pressure of molten metal at the time of measuring process, and consequently the circular solidified material 201 does not grow up backward beyond circular groove 212a. Moreover, since the peripheral surface of billet 2 is heated rapidly until next measuring process by the molten metal 3, the surface of the circular solidified material 201 which comes into contact with the billet 2 is kept in the appropriately softened state. Incidentally, the above described molten metal 3 is the material filled in the gap around the peripheral of the billet 2 at the time of measuring process while the billet 2 advances. Moreover, adhesion strength of the circular solidified material 201 to the billet 2 is not strong since the solidified material 201 is a solidified material which is turned rapidly when hot molten metal 3 touches comparatively low temperature of billet 2.

In addition, the gap between the inside diameter of the cylinder bore 211a of the melting cylinder 211 and the outside diameter of the billet 2 is formed to be a few mm so that the softened front end of the billet 2, which is enlarged slightly in diameter while advancing, does not interfere with the cylinder bore 211a. Thus molten metal 3 can enter backward behind the enlarged end of billet without being blocked, which avoids the existence of the space, into which the molten metal does not enter, and hence suppresses the fluctuation of the amount measured by the billet 2. This phenomenon will be easily understood by assuming such an opposite phenomenon that the enlarged front end of the billet 2 repeats its growing up and breakage, and so repeats touching or separating from the cylinder bore 211a. In this opposite phenomenon, the pushing area that functions as a piston area fluctuates actually.

In this way, the circular solidified material 201 seals the gap between the billet 2 and the melting cylinder 211 well and stably when billet 2 advances and pushes out molten metal 3 at the time of the measuring. The circular solidified material 201 naturally does not allow air and the like to intrude into the gap between the billet 2 and the melting cylinder 211, and prevents backward flow of molten metal 3, which also reduces frictional resistance of movement of the billet 2. Sealing action of this circular solidified material 201 utilizes effectively the characteristic of light metal material, especially that of magnesium alloy, that is, the characteristics of rapidly phase changing from solid to fluid because of its high coefficient of thermal conductivity, small thermal capacity, and small latent heat.

Above described circular solidified material 201 seals molten metal 3 surely. Therefore this type of melting cylinder 211 can be adopted in a large-sized injection molding machine which uses thicker diameter billet than a small-sized injection molding machine.

Next, the characteristic embodiments of the other components that relate to melting cylinder 11 of this invention are described. In the following description, melting cylinder 11 includes both of the first melting cylinder 111 and the second melting cylinder 211 as far as not specified.

First, such an embodiment is described with Fig. 1, that relates to the layout position of the connecting passage 13b, which is formed in the end plug 13 situated on the front end of the melting cylinder 11, and installation posture of the melting cylinder 11. The connecting passage 13b is formed as a space between the cylinder bore 11a and a upper cutout of a plug portion of the end plug 13 so as to be opened at the upper portion of the cylinder bore 11a. In this case, this cutout is formed by removing the upper part horizontally so as to make a D-shaped cross-section, or by slotting a rectangular groove such as a keyway for example. The melting device 10 that contains the melting cylinder 11 is arranged in the inclined posture at about 3 degrees with the front side high. With this arrangement of the connecting passage 13b, when preparatory injection molding operation commences first, air or inert gas

that has been trapped inside the melting cylinder 11 is surely purged. That is because air and gas is easy to gather in the upper part. Besides, the measuring becomes accurate since the phenomenon in which molten metal 3 over-flows into the injection sleeve 21 at unexpected timings which exclude the timing of measuring process is prevented by the arrangement of the connecting passage 13b and the inclined posture of the melting cylinder 11. In this case it is still better that the whole injection molding machine including the injection sleeve 21 and the mold clamping device 30 as well as the melting cylinder 11 is arranged in the inclined posture with its rear side low.

In such an embodiment, it is still better that the molten metal feeding member 15 comprises an opening and shutting device 70 as shown in Fig. 5. Fig. 5 is an enlarged cross-sectional view showing the structure of the molten metal feeding member 15 and its vicinity. In this drawing, the opening and shutting device 70 includes a valve seat 15b which is formed on a bottom of the material supplying hole 15a, a valve rod 71 which opens and shuts the material supplying hole 15a by touching or separating from the valve seat 15b, and a valve rod driving device 72 such as a fluid cylinder which drives the valve rod 71 goes up and down. Between the valve rod 71 and the material supplying hole 15a, a gap which becomes a flow channel of molten metal 3 is secured. The fluid cylinder 72 is fixed on a bracket 73 and the upper end of the valve rod 71 is connected to a piston rod 72a of the fluid cylinder 72 by a coupling 74. The opening and shutting device 70 of above described structure prevents the molten metal 3 from dropping at unexpected timings except for the measuring timing by opening the material supplying hole 15a only at the timing of measuring, since the molten metal 3 sometimes adheres to the side wall of the material supplying hole 15a. In addition, since the material supplying hole 15a opens and closes near its bottom end, there exists no side wall of the material supplying hole 15a where molten metal 3 may adhere and sometimes drop. In this way, the opening and shutting device 70 assures accurate measuring. Incidentally, in case this type of opening and shutting device

70 is provided, the pouring hole 17 is furnished on a cover 16 so that the valve rod 71 in material supplying hole 15a is not cooled down.

In case this type of opening and shutting device 70 is provided, the measuring may be performed under such a condition that molten metal is always filled with the gap between the valve rod 71 and the material supplying hole 15a. In this case, starting timing and ending timing for extruding (supplying) molten metal 3 by billet 2 is controlled to coincide with the timing of opening and shutting operation of the material supplying hole 15a, which decides the start and end of measuring operation. By above described measuring, the measuring is more accurately controlled. That is because no temperature fall occurs at the material supplying hole 15a and the valve rod 71, and also adhesion of molten metal 3 to those side wall is avoided, since the material supplying hole 15a is filled with the molten metal. Moreover, another operational effect, with which melting efficiency of molten metal 3 in the melting cylinder 11 is improved, is performed. The first is that the temperature fall of molten metal 3 is avoided, whereas said temperature fall occurs when molten metal 3 which faces to the connecting passage 13b touches inert gas. The second is that the preceding compression of the billet 2 in the melting cylinder 11 becomes possible and hence melting becomes easy.

Next a billet supplying device 40 is described. Fig. 6 is a cross-sectional view showing the billet supplying device, taken along line X - X at the central frame member 90 of Fig. 1. For example, this device comprises a hopper 41 for having plural billets 2 loaded in a lined up state, a chute 42 for causing the billet to drop sequentially in an aligned state, a shutter device 43 for catching the billet temporarily and allowing the billet to drop one by one, and a holder 44 for holding the billet concentrically with an axial center of the melting cylinder 11. Inside the hopper 41, a dividing plate 41a forming a reflex guide passage is arranged so that the billets 2 drop without building up. The shutter device 43 constitutes two stage shutter of an upper stage shutter and a lower stage shutter, namely a shutter plate 43a and a holding member 45, wherein the holding member 45 is a moving side of

the holder 44. This shutter device 43 allows billets 2 to drop one by one by alternate opening and shutting operation of the shutter plate 43a and the holding member 45. Reference numeral 43b denotes a fluid cylinder such as an air cylinder for moving the shutter plate 43a forward and backward. The holder 44 comprises one set of the holding member 45 and a holding member 46, a fluid cylinder 47 such as an air cylinder, and a guide member 48 provided below the chute 42, in which the holding members 45 and 46 hold the billet 2 by gripping from both sides with a minuscule gap leaving, the fluid cylinder 47 opens or closes the one side holding member 45, and the guide member 48 receives the billet 2 on a curved guide surface and leads it to the holding member 46 side. On the facing sides of the holding members 45 and the holding members 46, almost semicircular arc-shaped indents 45a and 46a, which have a diameter slightly larger than the outside diameter of the billets, are formed in such a manner that the centers of these indents 45a and 46a are aligned with the center of the cylinder bore 11a when the holding member 45 is closed. Thus the billet 2 supplied from the hopper 41 is held by the holder 44 concentrically with the center of the cylinder bore 11a. Such a billet supplying device 40 holds the billet 2 in the aligned state and makes the billet 2 fall one by one. Accordingly, it is not limited to the above described embodiment as long as it functions as described above. Incidentally, billet 2 may be heated preliminary outboard at low temperature for dehumidifying its surface.

Next the billet inserting device 50 is described. For example, as shown in Fig. 1, this device comprises a hydraulic cylinder 51, a piston rod 52 subjected to controlled movement backward and forward by the hydraulic cylinder 51, and a pusher 52a integrally formed with the end of the piston rod. The maximum movement stroke of the pusher 52a is set to the length that rather exceeds the overall length of the billet 2. The pusher 52a advances intermittently corresponding to one shot of injection amount at every time of measuring process. The position and the speed of the pusher 52a is detected by a position detection device, for

example such as a linear scales not shown in the drawing, and is fed back to a control device, not shown in the drawing.

Above described billet inserting device 50 makes the pusher 52a move backward greater length than the overall length of the billet 2 at the time of replenishing so as to ensure a space for billet 2. And then the billet inserting device 50 inserts the billet 2 into the melting cylinder 11 while advancing the pusher 52a. At the time of measuring process, the billet inserting device 50 causes intermittent advance of the pusher 52a and feeds specified amount of molten metal 3 into the injection sleeve 21, wherein the amount fed with one advance corresponds to one shot of injection amount. This type of billet inserting device 50 is not limited to a driving device of a hydraulic cylinder as long as it ensures the above described operation of the pusher 52a and hence it can be a well-known electrical driving device, which drives the pusher 52a converting rotational movement of a servo motor to linear movement by means of a ball screw or the like.

Each component of the plunger injection device 20, combined to above described melting device 10, is described in detail with Fig. 1. These components are not limited to such as described below because they are common to a conventional injection apparatus in a cold chamber die casting molding machine.

First, overall structure of the plunger injection device 20 is described. The connecting member 64 which connects the injection sleeve 21 to the plunger driving device 60 is a cylindrical member and has a barrier wall 64a at the position close to the front side. The barrier wall 64a has a through hole into which the plunger 22 is fitted with almost no gap and a collection pan 65 is detachably provided under the front side of the barrier wall 64a so as to prepare for leakage of molten metal 3. Also, a pouring hole 64b for pouring inert gas is provided at an upper side of the connection member 64. The connection member 64 having this type of structure is provided with a space 66 between the injection sleeve 21 and the barrier wall 64a. With this structure, even if molten metal 3 leaked out from the base end of the injection sleeve 21 a little, it is collected in the collection pan 65.

Also, since inert gas is poured into this space 66, air remained in the gap between the plunger 22 and the base end side sleeve bore 21a is purged. This type of purging ensures the preferable surroundings for preventing oxidization of material, especially in the case of magnesium molding. The amount of inert gas to be supplied can be a little because the gas is supplied only into the space 66 and the tiny gap between the injection sleeve 21 and the plunger 22.

Next, a plunger driving device 60 is described. For example as shown in Fig. 1, this device comprises a hydraulic cylinder 61, the piston rod 62 subjected to controlled movement by the hydraulic cylinder 61, and a coupling 63 for connecting the piston rod 62 and the plunger 22. The plunger 22 inserted in the injection sleeve 21 is driven in the longitudinal direction forward and backward by the piston rod 62 of the hydraulic cylinder 61. The position of the plunger 22 is detected by a position detection device, for example, such as a linear scales, not shown, and is controlled by a controller, not shown, to which this position is fed back. The positions to which the plunger 22 can retreat are set to the positions which are located backward from the material supply mouth 21h and its maximum stroke is in advance designed to be consistent with the maximum injection volume of the injection apparatus 1. This type of plunger driving device 60 is not limited to a driving device of a hydraulic cylinder, and hence is possible to be a electrical driving device, wherein the driving device 60 drives the plunger 22 converting rotational movement of a servo motor to linear movement by means of a ball screw or the like.

The plunger 22 is provided with a head section 22a having a slightly thinner diameter than the inside diameter of the injection sleeve 21 and a shaft section 22b having a diameter slightly thinner than the head section 22a. The head section 22a also has a piston ring (not shown) provided on its periphery.

This type of a plunger driving device 60 makes plunger 22 retreat behind the material supply mouth 21h at the time of measuring process, and after

measuring finished, makes plunger 22 advance with injection speed and injection amount. Then the driving device 60 controls holding pressure when necessary.

With the injection apparatus 1 of this invention constructed as above described, the injection molding operation is carried out as follows. To be easily understood, practical injection molding operation is described first. Before this molding operation commencing, plural billets 2 have been supplied into the melting cylinder 11 in advance and molten metal 3 equivalent to several shots of injection amount has been secured in the forward side of the melting cylinder 11. In this state, first of all, measuring operation is carried out. First, the plunger 22 retreats beyond the material supply mouth 21h, and then pusher 52 makes billet 2 advance at the specified amount. In case the opening and shutting device 70 is provided, opening operation of the valve rod 71 starts at the same time. By above described measuring operation, molten metal 3 for one shot is transferred from the melting cylinder 10 to the injection sleeve 21 through the molten metal feeding member 15. Generally, this operation is done after the molded articles that have been molded in the preceding operation are taken out and clamping of mold half is completed. At this time of measuring, the pressure of molten metal 3 never becomes so high since the material supplying hole 15a of the molten metal feeding member 15 is open. Therefore, the seal of molten metal 3 is surely done by the above described enlarged diameter seal member or the circular solidified material seal. In particular, in case the opening and shutting device 70 is provided and the material supplying hole 15a is always full of molten metal 3, opening operation of the valve rod 71 is done at the same time. Therefore the pressure of molten metal does not become particularly high.

Molten metal 3 measured in the injection sleeve 21 is maintained in a molten state by the heater band 23. At this time, inert gas prevents the oxidation of molten metal. Next, plunger 22 moves forward and injects molten metal for one shot into the cavity 34 as conventional. Next, conventional cooling of the molded articles is done, next mold half is opened, and then molded articles are taken out.

Next, the mold half is closed again and then measuring starts in the above described way. Molten metal 3 in the melting cylinder 11, which is consumed at every time of the measuring, is melted and replenished before the next measuring starts.

Every time the measuring described above is repeated, the billet 2 moves forward intermittently. When the injection of molten metal for one billet has been done, the replenishment of billet 2 is done. This replenishing operation starts after the position detector for the pusher 52a detects that the pusher 52a has advanced more than overall length of one billet. First, the billet inserting device 50 makes the pusher 52a retreat more than overall length of the billet 2 and ensures space behind the melting cylinder 11 for supplying the billet 2. Next, the billet supplying device 40 replenishes one billet 2 to the rear of the melting cylinder 11 and then the billet inserting device 50 pushes the billet 2 into the melting cylinder 11 so that the replenishing operation completes. At this time, the above described enlarged diameter seal member or the circular solidified material seal prevents the infiltration of air into the molten metal 3 in the melting cylinder 11 and backward flow of molten metal 3. Also, since the end surface and peripheral surface of the billet 2 are finished smooth, no air enters together with the billets. Therefore air is not intruded into the melting cylinder 11 once purge has been completed.

Next, operation of preparatory steps before above described practical injection molding operation is described. First, inert gas is injected for purging the air in the melting cylinder 11. Next, billet 2 loaded into the hopper 41 in advance is fed to the rear of the melting cylinder 11 by the billet supplying device 40, and is inserted into the melting cylinder 11 by the billet inserting device 50. In this initial stage, plural billets 2 are inserted in succession until they fills the melting cylinder 11. The inserted billet 2 begins to melt from its front end of the forward portion while being heated by the heater bands 12a to 12d and being pressed forward in the melting cylinder 11. After molten metal 3 for plural shots of injection amount is finally secured, molten metal 3 is transferred into the injection sleeve 21 while the plunger 22 retreats and the pusher 52 advances. After molten metal 3 is supplied

into the injection sleeve 21, the operation corresponding to the above described injection operation is carried out and air or inert gas mixed into the melting cylinder 11 when forming molten metal 3 first is purged. After this purge is completed, the preparatory molding operation are repeated many times and the molding conditions are adjusted and then the preparatory operation before molding completes.

The invention described above is not limited to the above described embodiments, and various modifications are possible based on the gist of this invention, and these modifications do not depart from the scope of the attached claims. In particular, with respect to specific devices, such devices that basic function is complying with the gist of the invention are included in this present invention.

INDUSTRIL APPLICABILITY

As described above, the injection apparatus in a cold chamber die casting molding machine of this invention makes it possible to supply molding material in the form of billets although adopting conventional plunger injection device. Therefore injection apparatus of this invention facilitates the handling of the material and realizes the efficient melting and measuring of molding material, while succeeding the characteristics of the injection by the cold chamber die casting molding machine and making the furnace of melting device unnecessary. Moreover, the injection apparatus of this invention facilitates its handling by simplifying of itself and makes the maintenance work easy.